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AN AUTOMATIC MOBILE SAMPLING AND GAGING UNIT

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by

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16. Abstracts The design and operation of a unit that would sample storm water runoff from various environments on either a time-proportioned or flow-proportioned basis is described. The unit is self contained and automatic. It is operable under all weather conditions. An automatic sampler separately collects chemical and bacterial samples. An automatic tape recording precipitation guage mechanically converts the depth of accumulated precipitation during a given peripd of time. The operation of the unit is dependent upon a sufficient amount of rainfall to start the electrical and cooling systems and a predetermined amount of runoff to activate the sampling section.

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AN AUTOMATIC MOBILE SAMPLING AND GAGING UNIT

by

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Introduction

A unit that would sample storm-water runoff from various environments on either a time-proportioned or flow-proportioned basis was developed during the urban storm-water runoff studies conducted by the Cincinnati Water Research Laboratory (CWRL) of the Federal Water Pollution Control Administration. It was necessary to design a self-contained and automatic unit that could be used for all environments and would be operable under all weather conditions.

Equipment Used

The equipment is housed in the shell of a 14-foot travel trailer as shown in Figure 1.

A gas engine-driven generator and battery plant mounted on the yoke of the trailer has an output of 2500 watts at 115/230 volts. The generator starts automatically when 0.1 inch of rainfall triggers a switch atop the trailer (see Figure 1). The value was arbitrarily selected as a minimum amount of rainfall to produce runoff. However, this value may be changed to suit a particular environment by increasing or decreasing the area of the receiving tray and/or the collecting vessel in which the switch is located.

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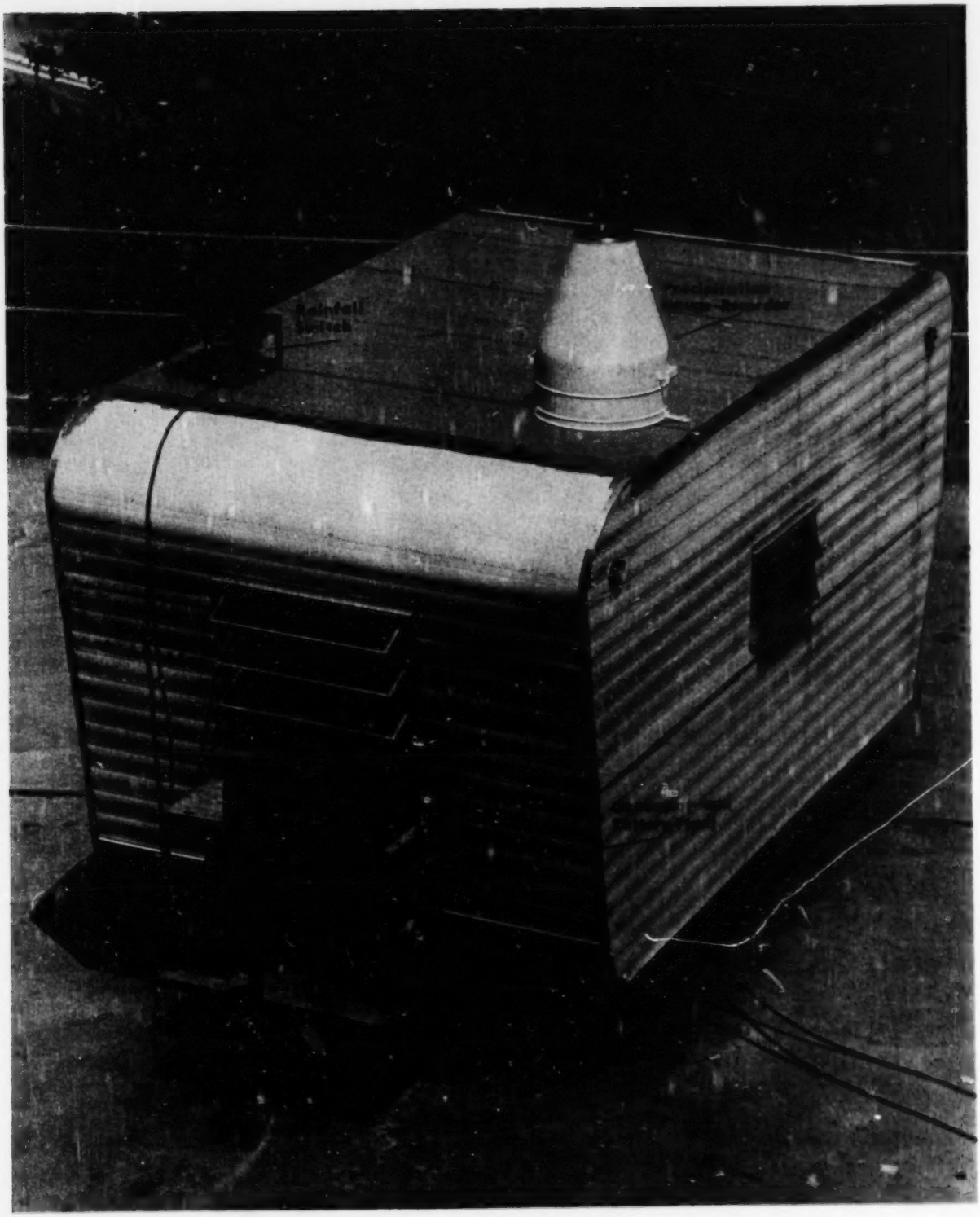

FIG. 1. AUTOMATIC MOBILE SAMPLING AND GAGING UNIT

Figure 2 shows the cooling system which begins operation when the power is turned on. The refrigeration unit, shown on the left, is designed to lower the cooling water temperature from 90 to 40° F in 1 hour. The closed system automatically circulates the cooling water, which is maintained at 40° F, in a bath around the sample containers and thus keeps the samples refrigerated. The cooling system is placed in operation as soon as the power is turned on so that the cooling water will be at or approaching operating temperature when samples are collected. Portions of the recirculating pump and reservoir tank are shown in Figure 2.

The automatic sampler begins operation when a pre-determined depth of storm-water runoff is reached in the sewer, culvert, drainage ditch, etc. This depth can be set depending on the position of a liquid level switch. When the switch is actuated, the sample pump and electronic control center start operation and continue as long as the level of storm-water runoff is at or above the depth for which the liquid-level switch is set.

Figure 3 shows the sample pump mounted for installation in a manhole. All connections are designed for ease of installation and removal. The pump is a positive-displacement diaphragm-type that can run dry without damage. The pump is rated at 8.5 gallons per minute (gpm) at a 3-foot head. The maximum dry-suction lift is 12 feet and maximum discharge head above pump is 13 feet. The pump was designed for a minimum of 3/4 inch I.D. pipe. A by-pass was installed so that

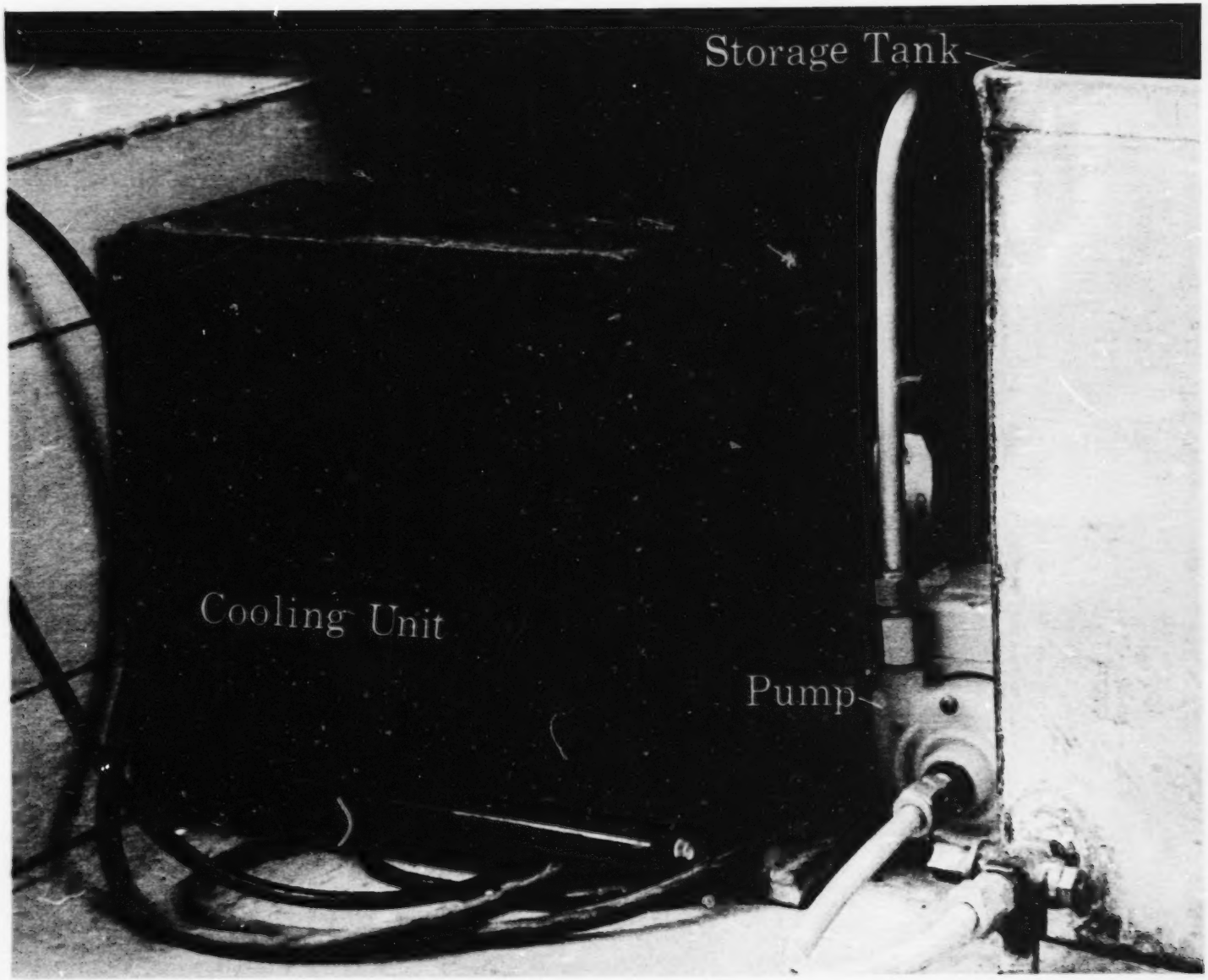

FIG. 2. COOLING SYSTEM FOR SAMPLE STORAGE WATER BATH

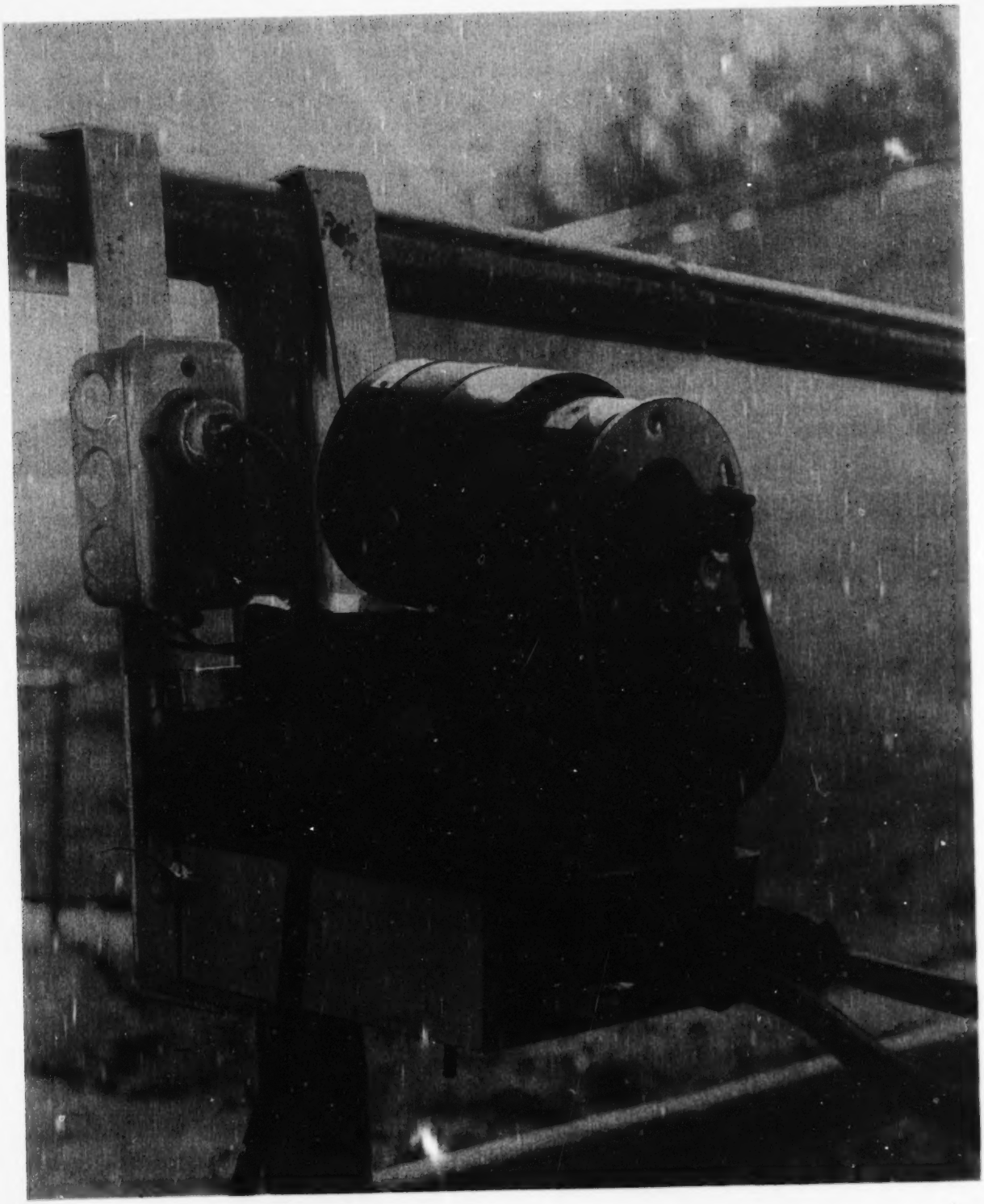

FIG. 3. SAMPLE PUMP

the pump could operate at maximum efficiency with smaller tubing. The inlet, waste lines and the control cables are shown in Figure 4. These locations were chosen to minimize exposing the tubing and cable when the trailer is positioned above a manhole. The pump is operating continuously when the liquid level switch is actuated to reduce the possibility of the pump failing to prime between samples.

Figure 5 shows the inlet float device which collects a sample at proportionately the same level regardless of the flow depth. The tubing is hinged at the bottom of the sewer or drainage ditch, with the float positioned downstream. There are four evenly spaced inlets in the tubing which allow contributions from several levels to the sample. This type of inlet device keeps the inlets under water and should provide a more representative sample.

Samples for chemical and bacterial analyses are automatically and separately collected, the latter in sterile containers. The sampling unit can collect 72 individual 1-gallon samples and/or a composite sample for chemical analysis, and, similarly, smaller portions for bacterial analysis. The composite sample size is adjustable to amounts within the limits of space in the trailer and the capacity of the pump and tubing. Discrete and composite samples can be collected independently or simultaneously.

The discrete sampler is shown in Figure 6. The bottles are held in place by aluminum racks equipped with resilient bumpers to minimize breakage. Each rack holds four 1-gallon bottles and serves as a carrier during handling and shipping of samples. The racks are

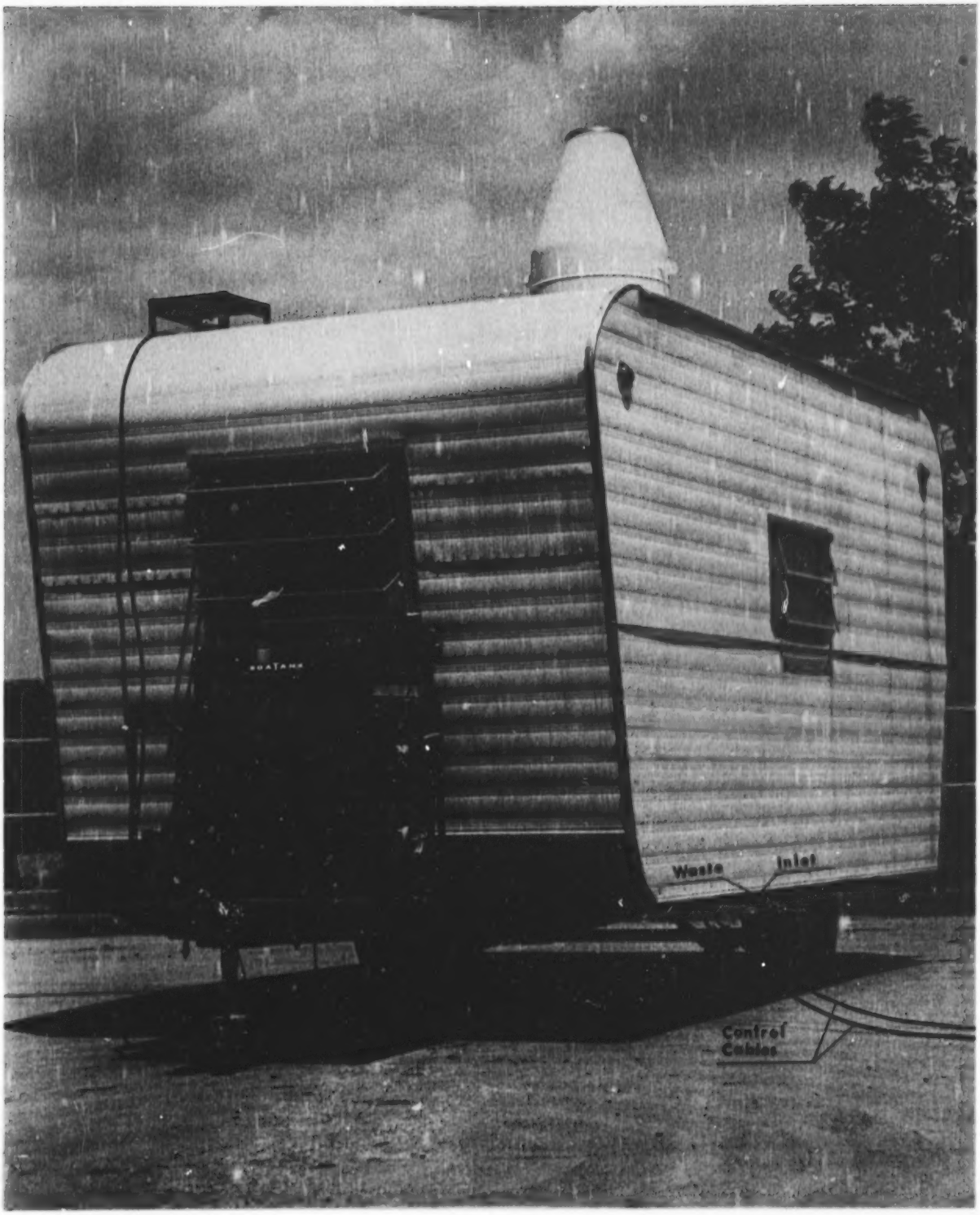

FIG. 4. MOBILE UNIT SHOWING WASTE INLET AND OUTLET CONNECTIONS, AND CONTROL CABLES

FIG. 5. SAMPLE INLET WITH HINGE AND FLOAT

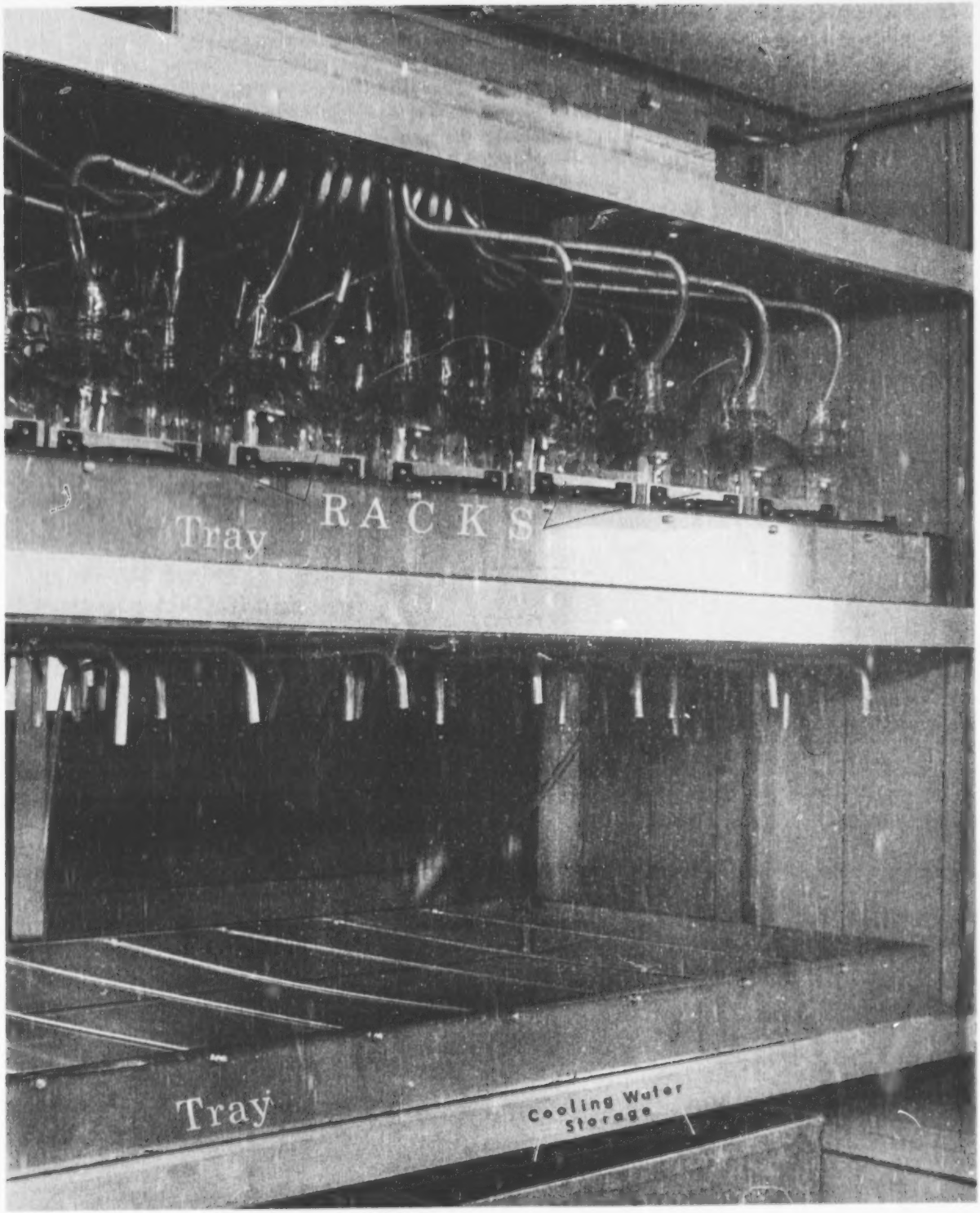

FIG. 6. SAMPLE STORAGE IN COOL WATER TRAYS

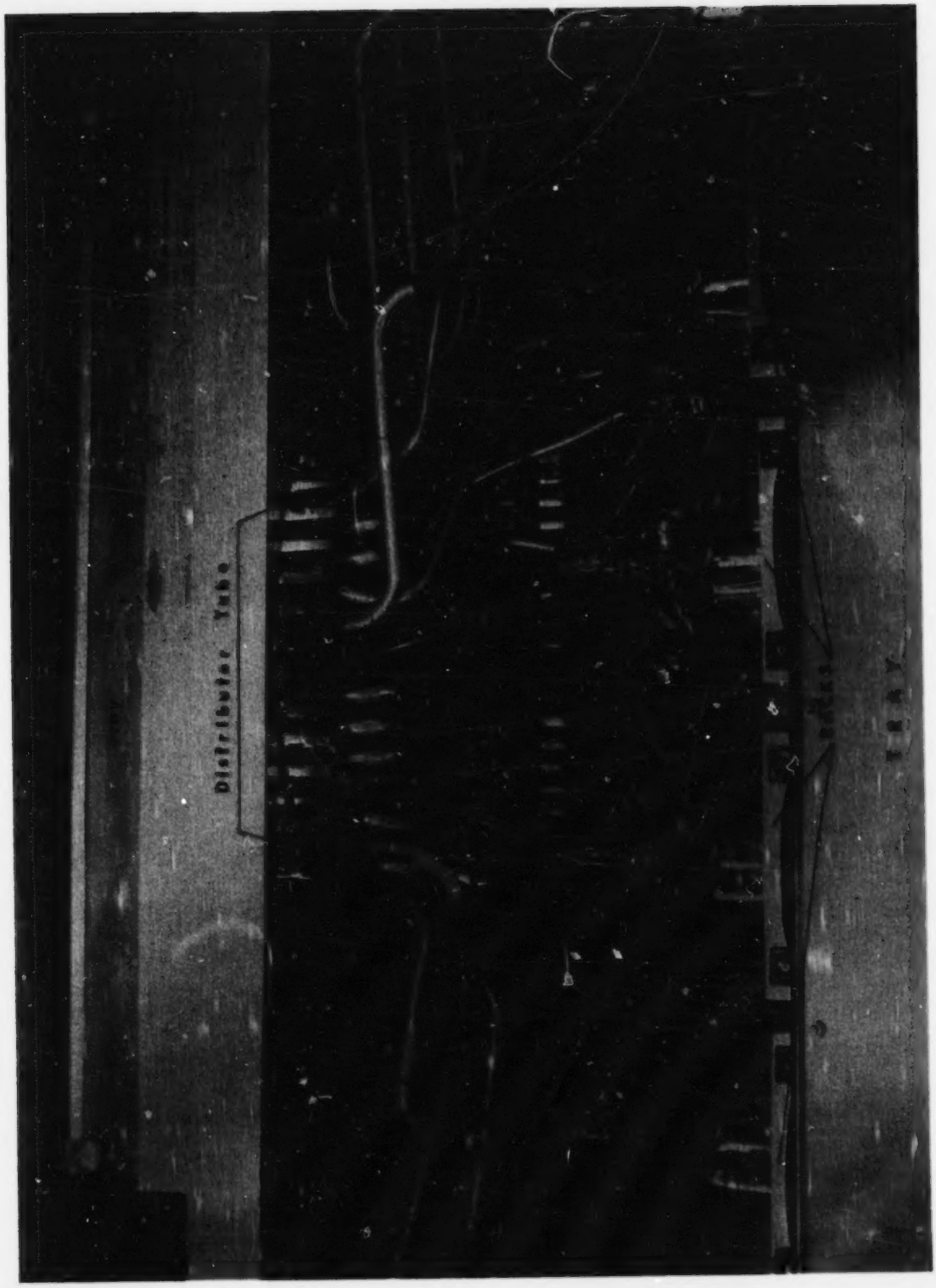

FIG. 7. LEADS FROM ROTARY DISTRIBUTOR TO SAMPLE BOTTLES

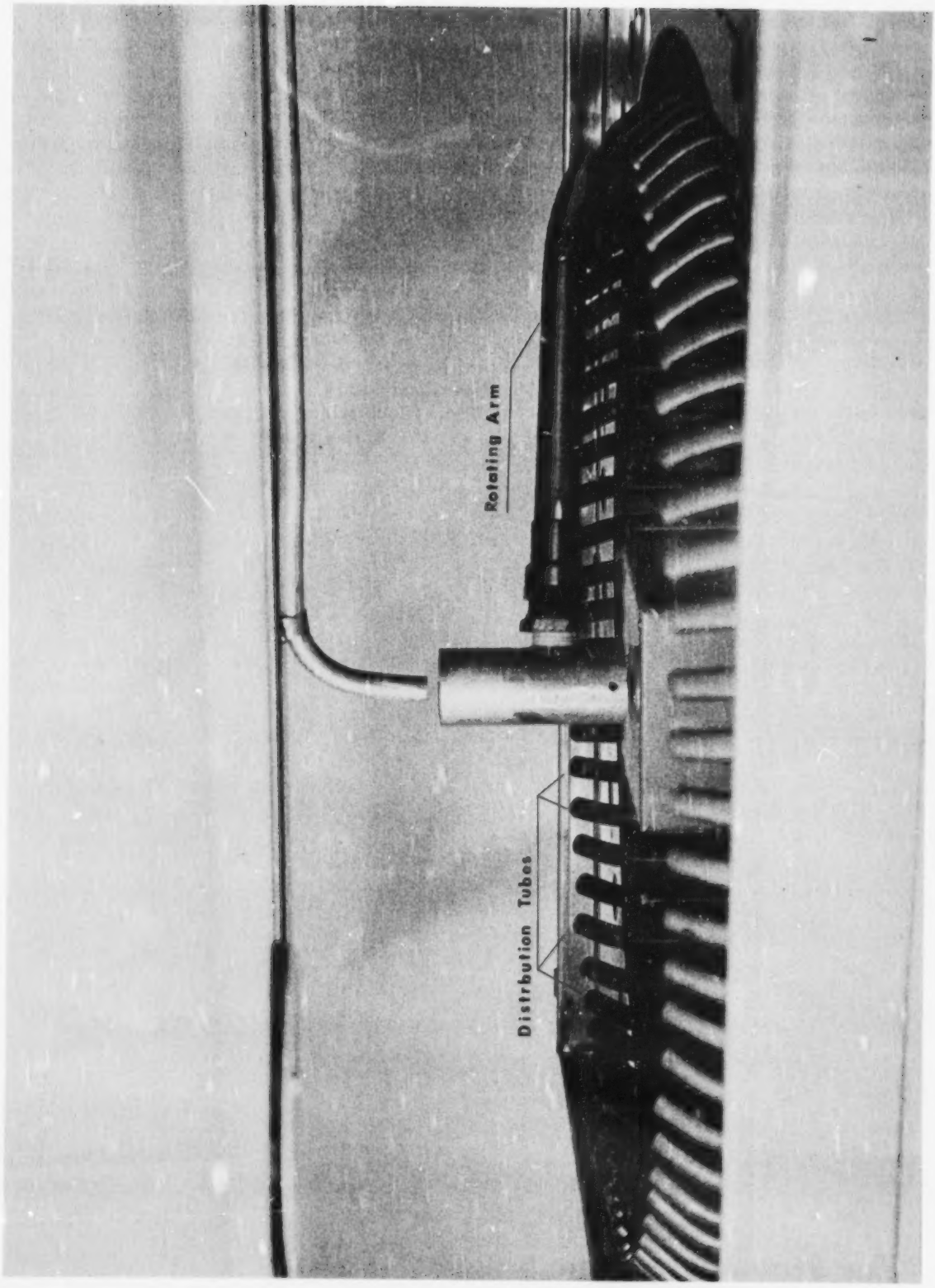

FIG. 8. ROTARY SAMPLE DISTRIBUTOR

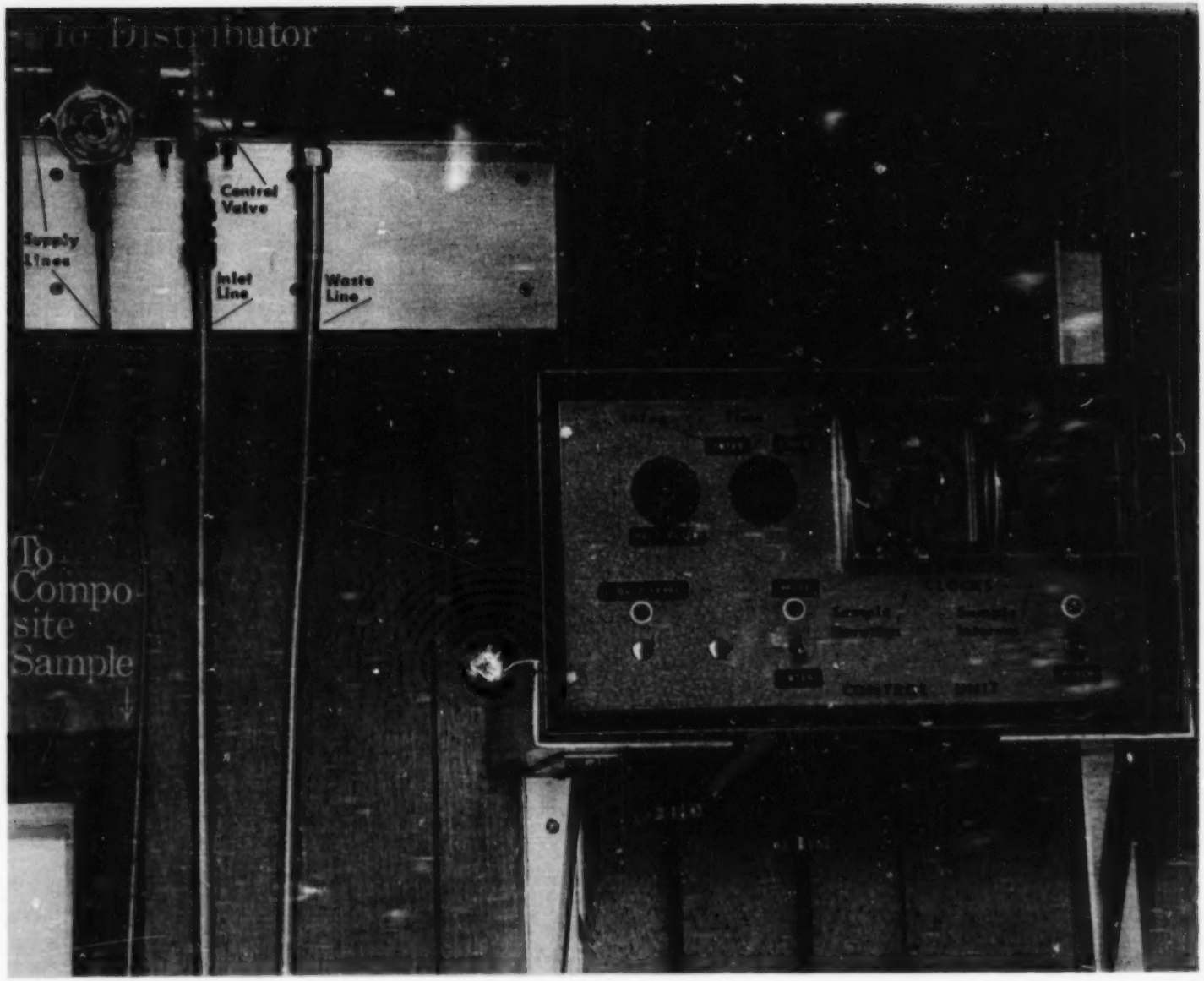

FIG. 9. CONTROL UNITS

FIG. 10. ROTARY DISTRIBUTOR DRIVE UNIT

equipped with rollers on one end to aid in removing the racks of full bottles from the trays. The trays hold the cooling water for refrigeration of the samples.

Figure 7 shows a bottom view of the distributor mechanism. The distributing mechanism shown in Figure 8 consists of a rotating arm and drive unit with switching provided on energization by a signal from the control unit, shown in Figure 9. The drive unit (Figure 10) is basically part of a 24-position rotating step relay assembled on a bracket with appropriate gearing to provide 72 positions per rotation.

The control unit (Figure 9) enables the operator to select either flow-proportioned or time-proportioned samples as indicated by the "Integ." and "Time" switches, respectively. When the switch is in "Time" position both clocks are in operation. The clock on the right controls the interval between samples and can be varied from 2 to 30 minutes. The clock on the left is in operation for either type of sample. It controls the 3-way motor-operated ball valve (Figure 9), and the distributor mechanism (Figures 8 and 9). An electric signal, which can be adjusted from 5 to 250 seconds in duration, closes the ball valve which diverts the sample to the distributor mechanism that has been triggered to collect a sample in the next bottle. When the signal is terminated the ball valve closes and the sample is pumped to waste.

An event recorder is connected in the circuit with the ball valve and distributor mechanism so that each sampling event is recorded on a strip chart. This provides a visual check on the sampling equipment along with the times the samples were collected.

When the switch is in the "Integ." position (Figure 9), the timer on the right is disconnected and the bubbler units (Figure 11) are placed in operation. Figure 11 shows the bubbler units, differential manometer, nitrogen tank, analog-to-digital recorders (ADR) and control unit. This system enables samples that are proportionate to the flow to be collected. Basically it consists of bubbler units which convert stage readings into area by means of a cam mechanism, and velocity readings from a pitot tube and differential manometer, and electronically multiplies the signals, producing an output equal to the flow.

The pitot tube, mounted on the inlet-float device (Figure 5), senses velocity at the 0.6-depth position approximating average velocity, regardless of flow depth. The stage reading bubbler is installed at the bottom of the sewer or drainage ditch. An ADR is connected to the output shaft of each bubbler unit. One ADR punch tape will contain the stage information of the storm-water runoff in the sewer or drainage ditch, while the other ADR punch tape will have the stage values from the differential manometer for the velocity. This information can be fed directly into a computer from which the actual flows can be calculated and the runoff hydrograph plotted. The bubbler unit consist of five major units:

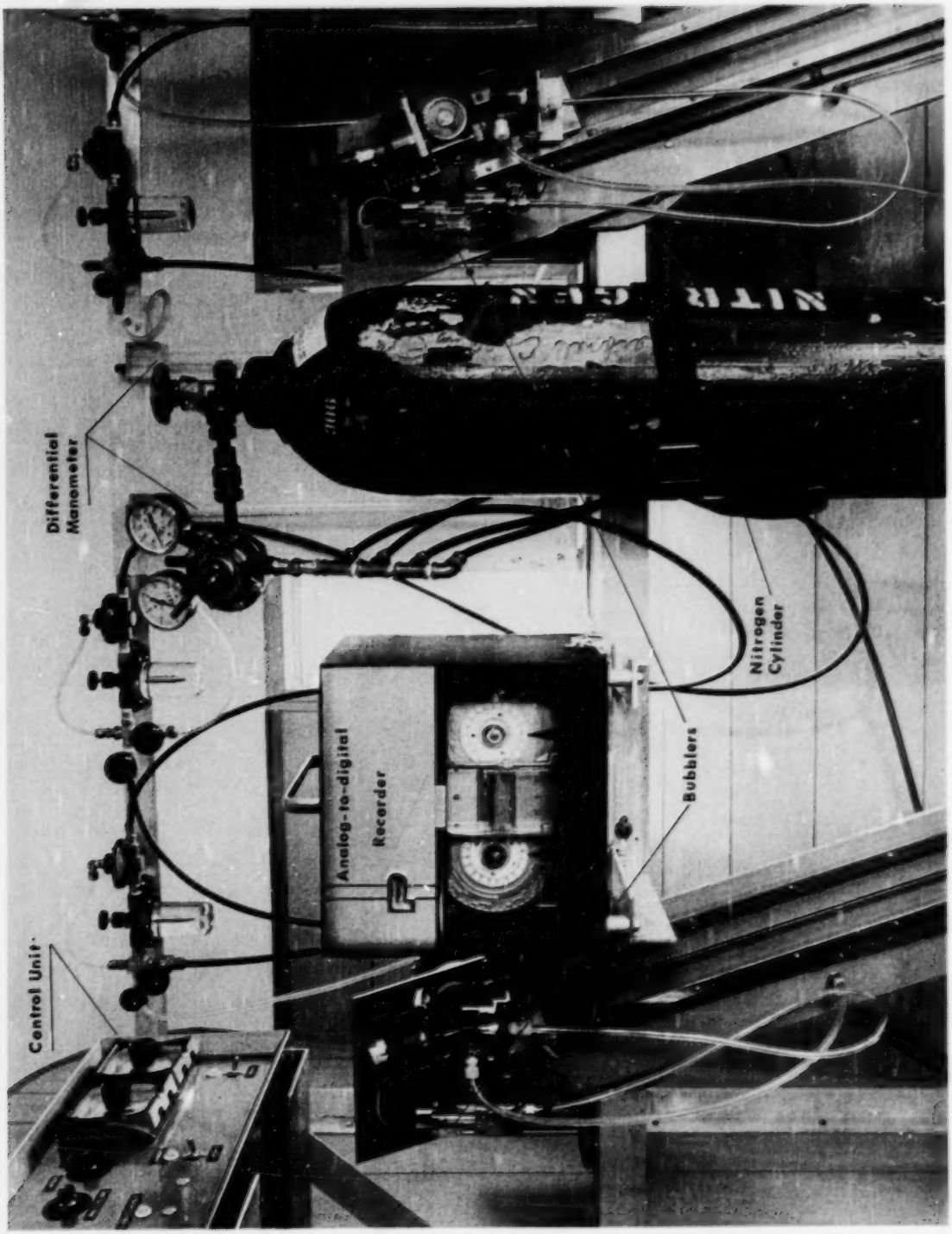

FIG. 11. FLOW SENSING AND RECORDING UNITS

1. The gas-purge system which provides a means of transmitting the pressure head of water to the manometer location of the unit (inside the trailer);

2. The servo-manometer assembly which converts the pressure in the sensing element of the gas-purge system to a shaft rotation for driving the ADR and the electronic control units;

3. The servo-control unit which provides the relay action necessary to permit the sensitive float switch to control the operation of the servo-motor;

4. The ADR which interprets the shaft rotation as variations in the water level and relates those variations to time;

5. The two electronic control units that are connected to the output shafts which interpret the shaft rotations;

   a. As variations in the water level (stage readings) and relate those variations through a cam action into area readings in relation to time; and

   b. As variations in the water velocity by means of a pitot tube and differential manometer (velocity is reflected as a change in the stage of one leg of the differential manometer) and relate those variations to time.

The output signal from the two electronic control units is integrated to provide a signal which represents the flow of the storm-water runoff. This signal actuates counters that are manually

preset to respond to the passage of a selected number of units of flow (say 25,000 gallons, or 100,000 gallons) at a measuring location. When the preset value is reached, the control unit is actuated and the ball valve and the distributor arm are actuated, thereby collecting a sample. A switch on the control unit (Figure 9) allows for pre-setting values for collecting a sample every unit, every 5 units, every 10 units, every 15 units, or every 20 units of flow. This enables the operator to select and preset the desired volume interval between samples.

A separate automatic tape recording precipitation gage accompanies the mobile sampler. This may be mounted on the trailer roof or elsewhere. A roof mounting is simulated in Figure 1. This unit mechanically converts the depth of accumulated atmospheric precipitation (rain and/or snow) during a given period of time, to a code disk position. The code disk position is recorded in a standard decimal code on punched paper tape at a 5-minute interval, that is suitable for automatic machine processing methods.

Operation Summary

The operation of the sampler is dependent on two factors - a sufficient amount of rainfall to start the electrical and cooling systems, and a predetermined amount of runoff to activate the sampling section. These values will be dictated by the environment studied. If a time-proportioned sample is desired, the control unit is set in the "Time" position which puts the timer clock into the circuit. The clock then measures off the pre-set time interval between samples, which can range from 2 to 30 minutes in duration. If a flow-proportioned sample is to be collected, the "INTEG" position is selected, and the bubbler units, differential manometer, ADR's and associated equipment are placed in the circuit. The volume interval between samples can be selected from five different ranges. When the runoff reaches or exceeds a pre-determined depth the pump operates continuously, pumping either to the distributor or to waste, depending on the cycle as set by the control unit.

The control unit regulates sample collection by controlling the operation of the 3-way motor-operated ball valve and the positioning of the distributor arm. An event recorder provides a visual check on the number of samples collected in addition to the collection times. The electrical and cooling systems operate until the samples are picked up, thereby keeping them refrigerated.

The amount of precipitation is measured and recorded on a punched tape. The runoff flow values are determined from punched

tapes, which provide separate values for stage (which is automatically converted to cross-sectional area) and velocity.

Summary and Conclusions

A completely self-contained, automatic and mobile sampling unit was designed and built to collect time-proportioned or flow-proportioned samples and measure flows from any environment. This unit fulfilled a long-standing need for a sampler that could readily collect samples and measure flows and not require any permanent or temporary structures to be erected. It is now readily possible to collect samples from a sewer, drainage ditch, or stream. The only change in equipment required is the insertion of a cam reflecting the cross section vs. depth function for the particular conduit. The data are recorded on punched tapes so that they can be directly computed for analyzing the results of the samples.

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